REMARKS

Reconsideration and allowance of the above application are respectfully requested. Applicant gratefully acknowledges the Examiner's indication that Claims 8, 11, 12, 17, and 20 are allowable.

As an initial matter, the undersigned hereby confirms the election of Group I, Claims 1-20 and 24-29 which was provisionally made in a telephone call with the Examiner on March 6, 2003. The non-elected Claims 21-23 have been canceled.

Claim 1 has been amended to correct the typographical errors and to comply with the Examiner's requirement. Claim 24 has also been amended to correct two typographical errors. These amendments do not add new matter and nor do they relate to patentability of Claim 1.

New claims, 30-32, have been added. Each new claim is fully supported by the original specification. No new matter is added.

Upon entry of the above amendments, Claims 1-20 and 24-32 are pending and under consideration.

We now discuss each rejection based on cited prior art.

Claims 13, 14, 24, and 25 stand rejected as allegedly being anticipated under 35 USC 102(b) by Knight. This contention, however, is respectfully traversed because Knight fails to disclose each feature in Claims 13, 14, 24, and 25.

In general, the pending claims of this application relate to devices including a tapered fiber section conformingly connected to a first single-mode fiber for light at a first wavelength at one side and a second single-mode fiber for light at a second wavelength at another side. Notably, the first and second fibers are different single-mode fibers for two different

wavelengths. This structural feature provides, among others, a unique optical coupling operation where light at the two different wavelengths can be evanescently coupled into and out of the tapered fiber section.

Claims 13, 14, 24, and 25 specifically recite the above features. Claims 13 and 14 recite the following combination of features:

> *an optical fiber coupler having a tapered fiber section formed of a fiber cladding material to form an optical waveguide based on interfacing between said fiber cladding material and air, a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section,*
>
> *wherein said tapered fiber section has a structure to support at least one waveguide mode at said first wavelength and one waveguide mode at said second wavelength.*

Knight, in stark contrast, discloses a tapered section formed in a middle of a monomode fiber, i.e., a single-mode fiber (Abstract, column 2 on page 1129, and column 1 on page 1130). Two opposite sides of the tapered fiber section connect to identical untapered single-mode fiber sections that support a single mode of light at the same optical wavelength.

Accordingly, Knight fails to disclose "a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section" as recited in Claims 13 and 14. In fact, Knight specifically teaches formation of the tapered section from the same single-mode fiber by heating and stretching a section of the same fiber (column 1 on page 1129).

Hence, in Knight's coupler, the untapered fiber section at one end of the tapered section is identical to the other untapered fiber section on the opposite side of the taper fiber section. therefore, Knight teaches away from Claims 13 and 14.

This difference in structure between Knight and Claims 13-14 is technically significant. It is known in the field of fiber optics that a single-mode fiber at a specified wavelength supports the fundamental mode for light at the specified wavelength but not higher order modes at the same specified wavelength. Assuming that Knight's coupler uses 1550-nm single-mode fiber (Knight, left column at lines 26-29 on page 1130), let us examine how Knight's coupler operates when a pump light at a shorter wavelength, e.g., around 980 nm, is received at one end of the coupler. The receiving end is formed from the same 1550-nm single mode fiber like the corresponding part on the opposite side of the coupler. Because the diameter of the 1550-nm single mode fiber is larger than that of a 980-nm single mode fiber, the receiving end of the coupler can support both the fundamental mode of the 980-nm light and higher order modes of the 980-nm light. Thus, it is not a single-mode fiber for light at 980 nm. The presence of higher order modes of the 980-nm light in the receiving end reduces the input optical power of the 980-nm light in the fundamental mode at 980 nm because part of input optical energy at 980 nm is in the higher order modes at 980 nm. In other words, only partial input power at 980 nm is transferred to the 980-nm fundamental mode at the receiving end and in the tapered region. Pump power carried by the higher order modes is lost or converted into higher order modes at 980 nm at the tapered region.

Therefore, when the Knight's coupler is used to couple the 980-nm fundamental mode into a WGM cavity and to couple 1550-nm light out of the WGM cavity, the coupling for the 980-nm

fundamental mode is less efficient as the 1550-nm fundamental mode. This compromises the optical pumping efficiency of the system.

If the Knight's coupler is formed from a 980-nm single-mode fiber, the above optical loss at the 980-nm fundamental mode is avoided. However, due to the small diameter of the 980-nm single-mode fiber, the insertion loss for the 1550-nm light will be large. Therefore, the coupling and transmission at 1550 nm are compromised.

Clearly, the use of the same single-mode fiber in Knight's coupler significantly limits its operations and performance in applications where two optical wavelengths are involved such as optical amplifiers and optically-pumped lasers based on WGM resonators.

In stark contrast, the devices recited in Claims 13 and 14 use a "hybrid" structure to mitigate this and other technical limitations in the Knight's coupler by connecting first and second single-mode fibers for different wavelengths to interface with a tapered fiber section. Assume that the second wavelength for the recited second single-mode fiber is longer (than the first wavelength for the recited first single-mode fiber. The second single-mode fiber has a diameter greater than that of the first single-mode fiber for the first wavelength. For example, the original specification of this application described the first single-mode fiber to support a single mode for light at 980 nm and the second single-mode fiber to support a single mode for light at 1550 nm (e.g., paragraph [0023] and FIG. 3). Due to this "hybrid" structure, the fundamental mode at 980 nm can be efficiently coupled through the 980-nm single-mode fiber without suffering the optical loss to higher order modes at 980 nm. At the same time, the output at 1550 nm at the tapered region can be transmitted through the 1550-nm single-mode fiber

without the insertion loss suffered when transmitting through the 980-nm single-mode fiber. This aspect of Claims 13 and 14 allows for formation of an efficient compact laser by coupling an optical cavity with a laser gain medium at the tapered section where a pump beam at 980 nm is introduced into the optical cavity from the 980-nm fiber while the generated 1550-nm laser light is coupled out of the cavity into the 1550-nm fiber.

Therefore, the "hybrid" structures recited in Claims 13 and 14 are different from Knight not only in structure but also in operation and performance. Under 35 USC 102(b), Claims 13 and 14 are distinctly different from and thus are patentable over Knight.

Claims 24 and 25 also provide "hybrid" structures by reciting "a tapered waveguide section", "a first waveguide section supporting a first single mode at said first wavelength" and "a second waveguide section supporting a second single mode at said second wavelength." Hence, for at least the above reasons set forth for Claims 13 and 14, Claims 24 and 25 are patentable over Knight.

In addition, Claims 24 and 25 are patentable over Knight on their own merits. For example, Claims 24 and 25 recite the first waveguide section to allow for "conversion of optical energy between said one mode at said first wavelength in said tapered waveguide section and said first single mode" and the second waveguide section to allow for "conversion of optical energy between said one mode at said second wavelength in said tapered waveguide section and said second single mode." Knight completely fails to disclose such first and second waveguide sections connected at two opposite sides of the tapered waveguide section. For this reason alone, Claims 24 and 25 are patentable over Knight.

The Patent Office rejects Claims 24 and 27 under 35 USC 102(b) as being anticipated by Takahashi. Applicants respectfully traverse the rejections because Takahashi, like Knight, also fails to disclose the hybrid structures of Claims 24 and 27. Takahashi processes a single fiber 19 in a single-mode configuration to form a tapered middle section. See, e.g., FIGS. 1 and 2(A)-(C). Nothing in Takahashi suggests anything related to two different fibers structured to support different single modes for light at different optical wavelengths. Hence, Claims 24 and 27 are patentable under 35 USC 102(b) over Takahashi.

In addition, with respect to Claim 27, the Office Action is incorrect to state that element 26 of Figure 1 and Column 7, lines 16-31 in Takahashi suggest evanescent coupling at the tapered section. Contrary to the contention in the Office Action on page 6, Takahashi does not teach evanescently coupling light of the fiber at the tapered section. Instead, Takahashi describes a tapered fiber structure with an enlarged end portion 20 to form a large optical aperture for efficiently coupling light from a light source 30 into the fiber. After the light is coupled from the light source 30 into the fiber, Takahashi suggests to confine the light in the fiber in order to direct the light along the fiber *without* being evanescently coupled out of the fiber.

In Column 7, lines 16-31 in Takahashi cited by the Office Action, Takahashi simply acknowledges the presence of evanescent effect. Light power Pa propagating within the fiber core 17 is partly going out to the mode radius area in the pair of the tapered portions due to an evanescent effect, and is combined with light power Pb propagating within the optical fiber clad. More specifically, Takahashi teaches that light is not

evanescently coupled out of the fiber but is confined in the fiber:

> *This mode of propagation results in combined light power (Pa+Pb) propagating within the optical fiber clad. As mode radius ω becomes small and the light beam propogates[sic] within second tapered portion 23 whose radius becomes large as the distance from the incident end-face increases beyond the midpoint of the tapered portions, the propagating light power (Pa+Pb) is concentrated into the area within radius a of the optical fiber core. The combined light power P=Pa+Pb finally converges into optical fiber core 17 so that light power P can propagate within optical fiber core 17.*

Column 7, lines 21-31 (emphasis added).

Therefore, for the above reason alone, Claim 27 is patentable over Takahashi.

Now turning to Claims 1-3 and 9, the Patent Office cites Takahashi in view of FIG. 3 of Kapron to reject the claims under 35 USC 103(a) as allegedly being obvious. Applicants respectfully traverse the rejections.

Similar to other pending claims discussed above, Claims 1-3 and 9 recite hybrid structures with first and second single-mode fibers for different wavelengths. Nothing in Takahashi and FIG. 3 of Kapron suggests such a hybrid structure and its operation. Hence, based on the arguments set forth for Claims 13, 14 and 24, the combined teaching of Takahashi and FIG. 3 of Kapron fails to disclose each feature of Claims 1-3 and 9. Accordingly, Claims 1-3 and 9 are patentable.

In addition, Claims 1-3 and 9 recite the second fiber having a second untapered fiber section and a second tapered fiber section which has one end being spliced to said another opposing end of said first tapered fiber section. Both

Takahashi and FIG. 3 of Kapron fail to disclose or suggest this feature. This distinction is hardly surprising because both Takahashi and FIG. 3 of Kapron do not disclose connecting two different single-mode fibers for different wavelengths together to form the tapered region for evanescently coupling light at two different wavelengths. This additional distinction further supports that Claims 1-3 and 9 are patentable.

New Claims 30-32 are also patentable based on the above arguments as well as on their own merits.

In view of the above, Applicants respectfully submit that all pending claims are distinctly patentable over cited prior art. Each and every objection or rejection raised in the Office Action has been fully addressed and overcome. Accordingly, the application should now be in full condition for allowance and an official notice of allowance is requested to be issued at an early date.

To expedite the prosecution of this application, the undersigned invites the Examiner to call to discuss any issues that may have been overlooked by this response so that Applicants could timely prepare and file a supplemental response to this Office Action if necessary.

Attorney's Docket No.:06618-736001

Please charge the $205 fee for the Petition for Extension of Time for two (2) months and any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

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